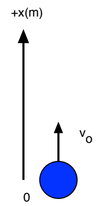
Your Name: ________________________

PHY203
Final Exam
5/4/15

Part 1

Solutions

Final1-S15



1. A ball is thrown straight up from the top of a cliff of height 150 m with an initial speed of v_o=12.0 m/s. (Ignore air resistance.)

a. At the highest point the ball reaches, find the acceleration of the ball (magnitude and sign) using the coordinate system given above.

-9.81 m/s2 **5**

b. At the highest point the ball reaches, find the velocity of the ball (magnitude and sign) using the coordinate system given above.

0 **5**

c. Find the height of the ball at its highest point measured from the top of the cliff.

$$0 = (12.0)^2 - 2(-9.81)(\Delta x)$$

10

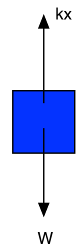
$$\Delta x = 7.34 m$$

d. Find the total time it takes the ball to hit the ground.

$$-150 = 0 + (12.0)t + \frac{1}{2}(-9.81)t^2$$ **10**

Solve quadratic equation

t = 6.89 s



2. A block with a mass of 5.50 kg is suspended from a spring. As a result, the spring is stretched by 15.0 cm.

a. Draw a free body diagram of the block on the figure above and to the right. **5**

b. Find the spring constant of the spring.

$kx - mg = 0$ **5**

$k = 360$ N/m

The block/spring is transported to Mars, where the acceleration due to gravity is 0.376 that of Earth.

c. Find the mass of the block on Mars.

still $m=5.50$ kg **5**

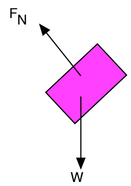
d. Find the weight of the block on Mars.

$W = mg = (5.50)(.376)(9.81 m/s2) = 20.3$ N **5**

e. If the block is put on a spring scale on a Martian elevator which accelerates downward with a magnitude of 2.50 m/s^2, find the reading on the spring scale.

$F_n - mg = ma$ **15**

$F_n = (5.50)[(.376)(9.81)-2.50] = 6.54$ N



3. A block (mass = 25.0 kg) is sliding with constant speed in a horizontal circle with a radius of R = 50.0 m on a frictionless banked track which makes an angle of 40^0 with respect to the ground. A side view is shown above. The period of the block around the track is T= 15.5 s.

a. Draw a free body diagram of the block on the figure above and to the right.

5

b. Find the speed of the block.

$v = (2\pi r)/T = (2\pi(50.0))/(15.5)$ **5**

$v = 20.3$ m/s

c. Find the magnitude of the centripetal acceleration acting on the block.

$a=v^2/r = (20.3)^2/(50.0)$ **10**

$a = 8.22$ m/s^2

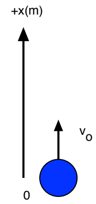
.

d. Find the magnitude of the normal force on the block. (Hints: the normal force is <u>not</u> given by mgcosθ; consider Newton's 2nd Law and the x- and y-components of the forces using the coordinate system in the figure).

$F_n \sin\Theta = ma$ **15**

$F_n = (25.0)(8.22)/(\sin(40.0^o) = 320$ N

Final1-S15alt



1. A ball is thrown straight up from the top of a cliff of height 100 m with an initial speed of v_o=14.0 m/s. (Ignore air resistance.)
a. At the highest point the ball reaches, find the acceleration of the ball (magnitude and sign) using the coordinate system given above.

-9.81 m/s2 **5**

b. At the highest point the ball reaches, find the velocity of the ball (magnitude and sign) using the coordinate system given above.

0 **5**

c. Find the height of the ball at its highest point measured from the top of the cliff.

$$0 = (14.0)^2 - 2(-9.81)(\Delta x)$$

10

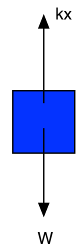
$$\Delta x = 9.99m$$

d. Find the total time it takes the ball to hit the ground.

$$-100 = 0 + (14.0)t + \frac{1}{2}(-9.81)t^2$$ **10**

Solve quadratic equation

t = 6.16 s



2. A block with a mass of 6.50 kg is suspended from a spring. As a result, the spring is stretched by 12.0 cm.

a. Draw a free body diagram of the block on the figure above and to the right.

5

b. Find the spring constant of the spring.

$kx - mg = 0$ **5**

$k = 531$ N/m

The block/spring is transported to Mars, where the acceleration due to gravity is 0.376 that of Earth.

c. Find the mass of the block on Mars.

still $m = 5.50$ kg **5**

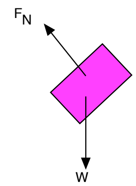
d. Find the weight of the block on Mars.

$W = mg = (6.50)(.376)(9.81 m/s2) = 24.0$ N **5**

e. If the block is put on a spring scale on a Martian elevator which accelerates downward with a magnitude of 2.00 m/s^2, find the reading on the spring scale.

$F_n - mg = ma$ **15**

$F_n = (6.50)[(.376)(9.81)-2.00] = 11.0$ N



3. A block (mass = 25.0 kg) is sliding with constant speed in a horizontal circle with a radius of R = 45.0 m on a frictionless banked track which makes an angle of 40^0 with respect to the ground. A side view is shown above. The period of the block around the track is T= 17.5 s.

a. Draw a free body diagram of the block on the figure above and to the right. **5**

b. Find the speed of the block.

$v = (2\pi r)/T = (2\pi(45.0))/(17.5)$ **5**

$v = 16.2$ m/s

c. Find the magnitude of the centripetal acceleration acting on the block.

$a=v^2/r = (16.2)^2/(45.0)$ **10**

$a = 5.80$ m/s^2

.

d. Find the magnitude of the normal force on the block. (Hints: the normal force is <u>not</u> given by mgcosθ; consider Newton's 2nd Law and the x- and y-components of the forces using the coordinate system in the figure).

$F_n \sin\Theta = ma$ **15**

$F_n = (25.0)(5.80)/(\sin(40.0^o) = 226$ N

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PHY203
Final Exam #2
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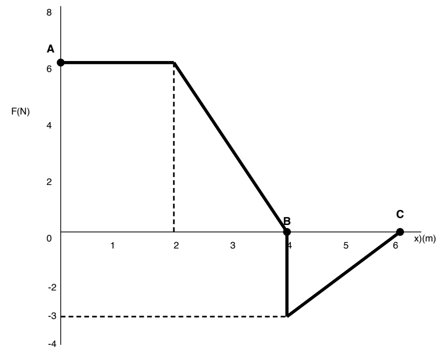
Part 2

Solutions

Final S15 Part2



1. An object with mass of 4.50 kg is subjected to the forces shown above.
a. Find the work done by the forces from point A to point B (magnitude and sign).

Work = Area = 12.0J + 6.00 J = 18.0 J **5**

b. Find the work done by the forces from point B to point C (magnitude and sign).

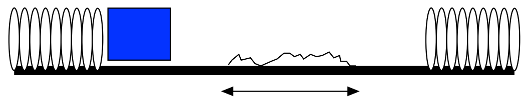
Work = Area = - 3.00 J **5**

c. If the object was traveling with a speed of 2.50 m/s at point A, find its speed at point C.

$$\frac{1}{2}mv_o{}^2 + W = \frac{1}{2}mv_f{}^2$$

$$v^2 = v_o{}^2 + \frac{2}{m}W = (2.50)^2 + \frac{2}{4.50}(18.0 - 3.00)$$ **10**

$$v = 3.59 m/s$$



2. Two identical springs with spring constants 500 N/m face each other on a horizontal surface. In the middle of the (otherwise frictionless) floor between them is a rough surface of D = 2.00 m in length with coefficient of kinetic friction of 0.300. Initially a block with mass 4.50 kg is pushed against the spring on the left until the spring is compressed by 0.650 m.

a. Find the potential energy of the compressed spring.

$$U = \frac{1}{2}kx^2 = \frac{1}{2}(500)(0.650)^2$$
$$U = 106J$$

5

b. Using Conservation of Energy, find the speed of the block after it has been released, the spring is uncompressed, and the block has not reached the rough surface.

$$U = 106J = \frac{1}{2}mv^2 = \frac{1}{2}(4.50)v^2$$
$$v^2 = \frac{2(106)}{4.50}$$
$$v = 6.85m/s$$

10

c. Find how much energy goes into friction as the block travels over the rough surface.

$$E_{th} = f_k \Delta s = \mu_k mg\Delta s$$
$$= (0.300)(4.50)(9.81)(2.00)$$
$$= 26.5J$$

10

d. Use Conservation of Energy to find the maximum compression of the spring on the right.

$$106J - 26.5J = \frac{1}{2}kx^2 = \frac{1}{2}(500)x^2$$
$$x = 0.564m$$

15

3. A bomb with mass of 3.50 kg is traveling at a constant speed of 2.50 m/s in the y-direction before it explodes. It suddenly explodes into 3 pieces. A 0.750 kg piece flies off in the positive x-direction with a speed of 3.50 m/s. A 1.25 kg piece flies off in the negative y-direction with a speed of 4.50 m/s. Find the velocity of the 3rd piece and write it in vector notation.

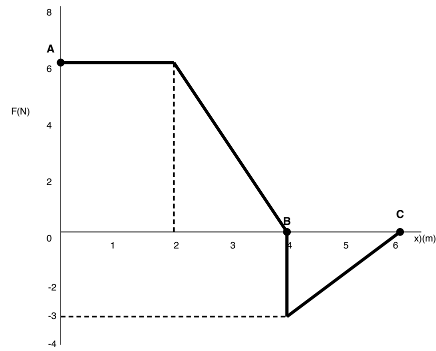
x: $$\begin{aligned} 0 &= (0.750)(3.50) + 0 + (1.50)v_{Cx} \\ v_{Cx} &= -1.75 m/s \end{aligned}$$

40

y: $$\begin{aligned} (3.50)((2.50) &= 0 + (1.25)(-4.50) + (1.50)v_{Cxy} \\ v_{Cxy} &= 9.58 m/s \end{aligned}$$

$$\vec{v} = (-1.75) m/s \hat{i} + (9.58) m/s \hat{j}$$

Final S15 Part2alt



1. An object with mass of 5.50 kg is subjected to the forces shown above.
a. Find the work done by the forces from point A to point B (magnitude and sign).

Work = Area = 12.0J + 6.00 J = 18.0 J **5**

b. Find the work done by the forces from point B to point C (magnitude and sign).

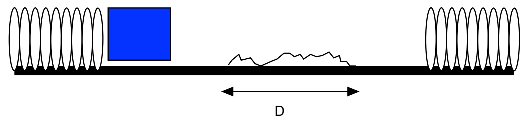
Work = Area = - 3.00 J **5**

c. If the object was traveling with a speed of 3.50 m/s at point A, find its speed at point C.

$$\frac{1}{2}mv_o{}^2 + W = \frac{1}{2}mv_f{}^2$$

$$v^2 = v_o{}^2 + \frac{2}{m}W = (3.50)^2 + \frac{2}{5.50}(18.0 - 3.00)$$ **10**

$$v = 4.21 m/s$$



2. Two identical springs with spring constants 400 N/m face each other on a horizontal surface. In the middle of the (otherwise frictionless) floor between them is a rough surface of D = 2.50 m in length with coefficient of kinetic friction of 0.300. Initially a block with mass 5.50 kg is pushed against the spring on the left until the spring is compressed by 0.650 m.

a. Find the potential energy of the compressed spring.

$$U = \frac{1}{2}kx^2 = \frac{1}{2}(400)(0.650)^2$$
$$U = 84.5J$$

5

b. Using Conservation of Energy, find the speed of the block after it has been released, the spring is uncompressed, and the block has not reached the rough surface.

$$U = 84.5J = \frac{1}{2}mv^2 = \frac{1}{2}(5.50)v^2$$
$$v^2 = \frac{2(84.5)}{5.50}$$
$$v = 5.54m/s$$

10

c. Find how much energy goes into friction as the block travels over the rough surface.

$$E_{th} = f_k\Delta s = \mu_k mg\Delta s$$
$$= (0.300)(5.50)(9.81)(2.50)$$
$$= 40.5J$$

10

d. Use Conservation of Energy to find the maximum compression of the spring on the right.

$$84.5J - 40.5J = \frac{1}{2}kx^2 = \frac{1}{2}(400)x^2$$
$$x = 0.469m$$

15

3. A bomb with mass of 4.50 kg is traveling at a constant speed of 3.00 m/s in the y-direction before it explodes. It suddenly explodes into 3 pieces. A 1.50 kg piece flies off in the positive x-direction with a speed of 3.50 m/s. A 1.25 kg piece flies off in the negative y-direction with a speed of 4.50 m/s. Find the velocity of the 3rd piece and write it in vector notation.

x: $0 = (1.50)(3.50) + 0 + (1.75)v_{Cx}$

$v_{Cx} = -3.00 m/s$

40

y: $(4.50)((3.00) = 0 + (1.25)(-4.50) + (1.75)v_{Cxy}$

$v_{Cxy} = 10.9 m/s$

$\vec{v} = (-3.00) m/s\hat{i} + (10.9) m/s\hat{j}$

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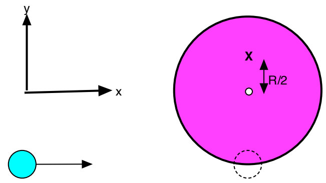
PHY203
Final Exam #3
5/4/15

Part 3

Solutions

Final3 S15



1. A ball with mass 2.50 kg and negligible size is traveling at a speed of 5.00 m/s in the positive x-direction. It strikes and sticks to the edge of a solid disk which has a mass of 6.00 kg and a radius of 0.800 m. The disk is pinned so that it pivots at the position X (as shown above) which is halfway between the center of the disk and its edge. (Take the z-direction as positive out of the paper.)

a. Find the moment of inertia of the disk about its pivot point.

$$I = I_{CM} + Mh^2 = \frac{1}{2}MR^2 + M(\frac{R}{2})^2 = \frac{3}{4}(6.00)(0.800)^2$$
$$= 2.88 \text{ kgm}^2$$

10

b. Find the angular momentum of the ball before the collision with respect to the pivot point of the disk and write it in vector notation.

$$\vec{L} = \vec{r}x\vec{p} = (1.20m)(2.50kg)(5.00m/s)\hat{k} = 15.0\frac{kgm^2}{s}\hat{k}$$

10

c. Find the magnitude of the angular velocity of the ball-disk combination immediately after the collision.

$$\vec{L}_i = \vec{L}_f = 15.0\hat{k} = I_f\vec{\omega}$$
$$I_f = 2.88 + md^2 = 2.88 + (2.50)(1.20)^2 = 6.48$$
$$\omega = \frac{L_f}{I_f} = \frac{15.0}{6.48} = 2.31 rad/s$$

20

2. A satellite of mass 450 kg circles a planet of radius 5.00x10^3 km at a distance of 500 km above the surface. The speed of the satellite is 230 m/s.
a. Find the mass of the planet.

$$F = \frac{mGM}{r^2} = m\frac{v^2}{r}$$

$$M = \frac{v^2 r}{G}$$

$$M = \frac{(230)^2 5.50x10^6 m}{6.67x10^{-11}} = 4.36x10^{21} kg$$

20

b. A rocket of mass 450 kg is launched from a height of 500 km above the surface of a planet with mass 7.50x10^{24} kg and radius 5.00x10^3 km. Find the escape speed of the rocket from that height.

$$\frac{1}{2}mv_e{}^2 - \frac{mGM}{R} = 0$$

$$v_e = \sqrt{\frac{2GM}{R}} = \sqrt{\frac{2(6.67x10^{-11})(7.50x10^{24})}{(5.50x10^6 m)}} = 1.35x10^4 m/s$$

10

3. A block of 3.50 kg is attached to a spring with spring constant 1.50 kN/m. At t = 0, the spring is stretched by 45.0 cm and released.

a. Write an equation of motion of the block.

$$\omega = \sqrt{\frac{k}{m}} = \sqrt{\frac{1.50x10^3}{3.50}} = 20.7 rad/s$$ **10**

x=(0.450m)cos((20.7rad/s)t)

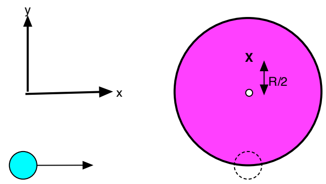
b. Find the maximum speed of the block.

$$v_{max} = \omega A = (20.7)(0.450) = 9.32 m/s$$ **5**

c. Find the velocity (magnitude and sign) when the block is first at a position of -0.300 m.

$$-0.300 = A\cos(\omega t) = 0.450\cos(20.7t)$$
$$20.7t = \cos^{-1}(-0.300/0.450) = 2.30; t = 0.111s$$
$$v = \frac{dx}{dt} = -\omega A\sin(\omega t) = -(20.7)(0.450)\sin[(20.7)(0.111)]$$
$$= -6.94 m/s$$ **15**

Final3 S15 alt



1. A ball with mass 3.50 kg and negligible size is traveling at a speed of 5.00 m/s in the positive x-direction. It strikes and sticks to the edge of a solid disk which has a mass of 6.00 kg and a radius of 0.600 m. The disk is pinned so that it pivots at the position X (as shown above) which is halfway between the center of the disk and its edge. (Take the z-direction as positive out of the paper.)

a. Find the moment of inertia of the disk about its pivot point.

$$I = I_{CM} + Mh^2 = \frac{1}{2}MR^2 + M(\frac{R}{2})^2 = \frac{3}{4}(6.00)(0.600)^2$$
$$= 1.62 \text{ kgm}^2$$

10

b. Find the angular momentum of the ball before the collision with respect to the pivot point of the disk and write it in vector notation.

$$\vec{L} = \vec{r}x\vec{p} = (0.900m)(3.50kg)(5.00m/s)\hat{k} = 15.8\frac{kgm^2}{s}\hat{k}$$

10

c. Find the magnitude of the angular velocity of the ball-disk combination immediately after the collision.

$$\vec{L}_i = \vec{L}_f = 15.8\hat{k} = I_f\vec{\omega}$$
$$I_f = 1.62 + md^2 = 1.62 + (3.50)(0.900)^2 = 4.46$$
$$\omega = \frac{L_f}{I_f} = \frac{15.8}{4.46} = 3.54 rad/s$$

20

2. A satellite of mass 550 kg circles a planet of radius $5.00x10^3$ km at a distance of 800 km above the surface. The speed of the satellite is 280 m/s.
a. Find the mass of the planet.

$$F = \frac{mGM}{r^2} = m\frac{v^2}{r}$$

$$M = \frac{v^2 r}{G}$$

20

$$M = \frac{(280)^2 5.80x10^6 m}{6.67x10^{-11}} = 6.82x10^{21} kg$$

b. A rocket of mass 550 kg is launched from a height of 800 km above the surface of a planet with mass $6.50x10^{24}$ kg and radius $5.00x10^3$ km. Find the escape speed of the rocket from that height.

$$\frac{1}{2}mv_e{}^2 - \frac{mGM}{R} = 0$$

10

$$v_e = \sqrt{\frac{2GM}{R}} = \sqrt{\frac{2(6.67x10^{-11})(6.50x10^{24})}{(5.80x10^6 m)}} = 1.22x10^4 m/s$$

3. A block of 4.50 kg is attached to a spring with spring constant 1.50 kN/m. At t = 0, the spring is stretched by 55.0 cm and released.

a. Write an equation of motion of the block.

$$\omega = \sqrt{\frac{k}{m}} = \sqrt{\frac{1.50x10^3}{3.50}} = 18.3 rad/s$$

10

x=(0.550m)cos((18.3rad/s)t)

b. Find the maximum speed of the block.

$$v_{max} = \omega A = (18.3)(0.550) = 10.1 m/s$$

5

c. Find the velocity (magnitude and sign) when the block is first at a position of -0.300 m.

$$-0.300 = A\cos(\omega t) = 0.550\cos(18.3t)$$
$$18.3t = \cos^{-1}(-0.300/0.550) = 2.15; t = 0.117 s$$
$$v = \frac{dx}{dt} = -\omega A\sin(\omega t) = -(18.3)(0.550)\sin[(18.3)(0.117)]$$
$$= -8.44 m/s$$

15